

# Does the relative importance of MMR vaccine concerns differ by degree of parental vaccine hesitancy?

## An exploratory study

Charitha Gowda,<sup>1</sup> Sarah E. Schaffer,<sup>2</sup> Kristin Kopec,<sup>2</sup> Arielle Markel<sup>2</sup> and Amanda F. Dempsey<sup>3,\*</sup>

<sup>1</sup>Division of Infectious Diseases; University of Pennsylvania; Philadelphia, PA USA; <sup>2</sup>Child Health Evaluation and Research Unit; Department of Pediatrics; University of Michigan; Ann Arbor, MI USA; <sup>3</sup>Children's Outcomes Research Program; Department of Pediatrics; University of Colorado - Denver; Aurora, CO USA

**Keywords:** measles, mumps, rubella, vaccine hesitancy, vaccination barriers, vaccination intention

**Abbreviations:** MMR, measles, mumps and rubella; VHP, vaccine-hesitant parents

**Background:** There has been a rise in the number of vaccine-hesitant parents (VHPs) in the US, many of whom express reservations about administering the MMR vaccine to their children. We studied the relative importance of attitudinal barriers to MMR vaccination among VHPs with differing levels of MMR vaccine-hesitancy.

**Results:** Our study population included 79 Michigan parents who initially screened positive for MMR vaccine-hesitancy. Within this sample, 47% of parents were unsure about their vaccination intentions and 20% expressed negative intentions, while a third (33%) of parents had positive vaccination intentions when further questioned. After grouping the barriers in our study into four underlying factors, parents with negative vaccination intentions had statistically significant higher factor score for the factor "risks versus benefits" and a statistically significant lower mean score for "vaccine importance," compared with parents with unsure or positive intentions.

**Methods:** We performed a cross-sectional exploratory analysis of a parental survey that assessed common vaccination barriers among MMR vaccine-hesitant parents in Michigan. The outcome of interest was parental MMR vaccination intention, measured on an 11-point scale, with higher numbers corresponding to greater intent. The relative importance of identified barriers to MMR vaccination was assessed across levels of vaccine hesitancy. Exploratory factor analysis was performed to identify underlying attitudinal constructs and assess if these constructs' importance varied depending on the degree of parental vaccine hesitancy.

**Conclusions:** In this exploratory study we found that vaccine-specific concerns have varying salience for parents based on their vaccination intention. Thus, future educational programs likely should tailor messages based on the degree of vaccine hesitancy expressed in their target populations in order to improve their overall effectiveness.

### Introduction

US parents are increasingly choosing to delay or omit certain vaccines, or pursue alternative vaccine schedules (i.e., those not recommended by the Centers for Disease Control and Prevention). Such "vaccine hesitant parents" (VHPs) choose these vaccination decisions primarily due to concerns about vaccine safety and misperceptions about the risks and benefits.<sup>1–8</sup> At least one in four parents expresses serious reservations about the recommended childhood vaccine schedule and could thus be broadly categorized as a VHP.<sup>9,10</sup> Furthermore, vaccine hesitancy appears to be increasing—at a national level the proportion of parents who "have concerns about vaccines" rose from 19% in 2000 to 50% in 2009.<sup>4,8</sup> Additional evidence supporting the increase in VHPs is the steady rise in non-medical vaccine exemptions over

the last several years.<sup>5</sup> Of all the recommended childhood vaccines, the measles, mumps and rubella (MMR) vaccine is one of the most frequently questioned vaccines by parents regarding its safety and necessity,<sup>9,11–14</sup> in part driven by prominent media attention regarding a purported (and subsequently disproven) link between this vaccine and autism.<sup>15–17</sup> As a result, there have been community outbreaks of measles and mumps throughout the US, particularly among unvaccinated populations.<sup>18–23</sup> Approximately 65% of recent measles cases in the US are thought to be "preventable"—meaning that the affected person (child) should have been vaccinated with MMR based on their age, but was not.<sup>23</sup>

Several studies have identified important barriers to MMR vaccination including concerns about vaccine safety, side effects or immune system overload, and perceived low risk for the

\*Correspondence to: Amanda F. Dempsey; Email: amanda.dempsey@ucdenver.edu  
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**Table 1.** Baseline demographics of study population, categorized by degree of MMR vaccine hesitancy

Socio-demographic characteristic	Vaccination intention category <sup>a</sup>			P-value
	Negative % (n)	Unsure/neutral % (n)	Positive % (n)	
Total Sample	20% (16)	47% (37)	33% (26)	
Parent's age				
≤ 24 y	12% (2)	24% (9)	12% (3)	0.185
25 to 34 y	44% (7)	37% (14)	65% (17)	
35 to 44 y	44% (7)	27% (10)	19% (5)	
46 to 55 y	0% (0)	11% (4)	4% (1)	
Child's age				
0 to 12 mo	31% (5)	49% (18)	50% (13)	0.121
13 to 23 mo	0% (0)	19% (7)	8% (2)	
2 to 3 y	19% (3)	16% (6)	19% (5)	
4 to < 6 y	50% (8)	16% (6)	23% (6)	
Child's gender				
Female	56% (9)	57% (21)	42% (11)	0.489
Race/ethnicity				
Caucasian	50% (8)	54% (20)	81% (21)	0.076
African-American	38% (6)	27% (10)	4% (1)	
Hispanic	6% (1)	5% (2)	15% (4)	
Other	6% (1)	14% (5)	0% (0)	

<sup>a</sup>Participants were divided into three mutually exclusive categories of vaccine hesitancy based on their responses to the statement, "I plan to have my child get the MMR vaccine [at the recommended ages] if recommended by my child's doctor." Responses followed an 11-point scale, where higher values corresponded to greater agreement with the statement. Parents who responded with a score ≤ 4 were classified as having "negative vaccination intention," score of 5 indicated "unsure/neutral intention," and a score > 5 represented "positive vaccination intention." Abbreviations: MMR, measles, mumps, rubella vaccine.

diseases prevented by the MMR vaccine.<sup>11-14,24</sup> These studies provide a framework for developing interventions to improve parental attitudes about MMR vaccines. What remains unclear, however, is the relative importance of these barriers in influencing vaccination intention and uptake among VHPs. Studies show that VHPs are a diverse population with varying levels of vaccine hesitancy and differing informational needs.<sup>9,25,26</sup> Recent studies have developed valid and efficient tools to identify and categorize VHPs that differ in the "degree" or "types" of vaccine hesitancy they have.<sup>10,27-29</sup> These tools could be used to provide targeted or tailored information to these parents that better address their unique MMR vaccination concerns. In order to provide effective information to motivate change in these parents' MMR vaccination intention, it is critical to understand the specific concerns that inhibit these parents from following the recommended vaccination schedule, and how these concerns may differ among parents with different "degrees" of vaccine hesitancy. With this in mind, we performed an exploratory study that examined the relative importance of different attitudinal barriers to MMR vaccination among MMR vaccine-hesitant

parents who were subdivided based on their degree of hesitancy for the vaccine. We hypothesized that the top vaccination barriers would vary among VHPs depending on their level of vaccine hesitancy.

## Results

A total of 79 participants were enrolled between June and December 2011, the majority of whom was Caucasian, younger than 35 y of age and had children less than 2 y old. There was an even distribution of female and male children. Although all parents in the study screened positive for MMR vaccine-hesitancy at the initial eligibility assessment, approximately 33% (26 parents) reported at the time of the baseline survey that they would likely have their children vaccinated if recommended by their physician (Table 1). There were no statistically significant differences in any of the demographic characteristics assessed by vaccination intention category.

Among all study parents, the top two barriers to MMR vaccination reflected parental concerns that were not specific to the MMR vaccine but instead related to the number of vaccines recommended for young children. The statements "Children receive too many vaccines," and "I worry that giving all the recommended vaccines will overload my child's immune system" both had overall mean scores of 3.58 out of 5 (higher scores correspond to greater agreement with the statement). However, the remaining barriers had notably different degrees of salience depending on the parents' vaccination intention category. Among parents who were unsure or had negative vaccination intentions, only one of the top 5 barriers identified addressed the potential safety of the MMR vaccine, as demonstrated by the statement, "I'm worried the MMR vaccine will cause other health problems for my child" (mean scores of 3.58 and 3.94, respectively, for parents with unsure or negative vaccination intentions). The other salient barriers for parents with negative vaccination intentions included a perceived low risk of contracting measles, mumps or rubella (mean score 4.0) and preference for natural over vaccine-induced immunity (mean score 3.63). In contrast, parents with positive vaccination intentions identified concerns about the MMR vaccine causing autism and other health problems as two of the top 5 barriers (mean scores of 2.96 and 3.5, respectively). Interestingly, this group of parents had a relatively weak belief that the MMR vaccine was effective in preventing measles, mumps or rubella (mean score 1.04; reverse-coded score 3.96), while parents who had negative or unsure intentions about vaccinating their child actually reported higher perceived effectiveness of the MMR vaccine (Table 2).

To determine if the individual barriers could be conceptually grouped, we performed an exploratory factor analysis. Due to small sample size, this was done using the entire study population. Four factors were identified as conceptually meaningful and could describe the variation among responses. Two items were dropped from the final factor analysis because they did not load strongly onto a single factor ("I don't know enough about the MMR vaccine to decide if my child should get it," and "The MMR vaccine has not been on the market long enough to ensure

**Table 2.** Mean score for each barrier among the different categories of vaccine-hesitant parents\*

Barrier	Vaccination intention category <sup>a</sup>		
	Negative	Unsure/Neutral	Positive
	Mean (SD)	Mean (SD)	Mean (SD)
Children receive too many vaccines.	<b>3.88 (1.59)</b>	<b>3.65 (1.38)</b>	<b>3.31 (1.44)</b>
I worry that giving all the recommended vaccines will overload my child's immune system.	<b>3.88 (1.36)</b>	<b>3.65 (1.42)</b>	<b>3.31 (1.44)</b>
I am worried about the safety of the MMR vaccine.	<b>3.94 (1.12)</b>	<b>3.58 (1.04)</b>	1.0 (1.2)
The MMR vaccine is effective in preventing the diseases measles, mumps, and rubella. <sup>b</sup>	2.69 (1.49)	3.30 (1.33)	<b>3.96 (1.18)</b>
Having my child get the MMR vaccine would help to protect others. <sup>b</sup>	2.38 (1.26)	<b>3.54 (1.17)</b>	2.38 (1.27)
I'm worried the MMR vaccine will cause my child to have autism.	3.31 (1.35)	2.89 (1.15)	<b>2.96 (1.04)</b>
I'm worried the MMR vaccine will cause other health problems.	3.56 (1.26)	3.19 (1.13)	<b>3.5 (1.1)</b>
My child is at low risk for getting the diseases measles, mumps or rubella.	<b>4.0 (0.89)</b>	3.35 (1.25)	1.31 (1.46)
I would rather have my child develop natural immunity to measles, mumps or rubella than have them get the MMR vaccine.	<b>3.63 (1.15)</b>	2.70 (1.22)	2.08 (1.16)
I would regret not getting my child vaccinated with MMR if they later go on to get measles, mumps or rubella. <sup>b</sup>	2.88 (1.31)	<b>3.92 (1.28)</b>	2.0 (1.44)
Healthy children don't need to be vaccinated against measles, mumps or rubella.	2.75 (1.34)	1.97 (1.28)	1.65 (1.29)
MMR vaccines are important for keeping my child healthy. <sup>b</sup>	1.38 (1.20)	2.86 (1.06)	2.81 (1.39)
Risks from MMR vaccination outweigh the benefits.	2.81 (1.52)	2.68 (0.91)	1.69 (1.38)
The MMR vaccine has not been on the market long enough to ensure it is safe and beneficial.	2.63 (1.31)	2.78 (0.95)	2.38 (1.6)
I don't know enough about the MMR vaccine to decide if my child should get it.	2.13 (1.31)	3.35 (1.18)	1.78 (0.91)
Giving my child the MMR vaccine would result in a lot of side effects.	3.44 (0.96)	2.46 (0.84)	1.15 (1.46)

\*The top five barriers in each vaccine intention category are bolded. <sup>a</sup>Participants were divided into three mutually exclusive categories of vaccine hesitancy based on their responses to the statement, "I plan to have my child get the MMR vaccine [at the recommended ages] if recommended by my child's doctor." Responses followed an 11-point scale, where higher values corresponded to greater agreement with the statement. Parents who responded with a score  $\leq 4$  were classified as having "negative vaccination intention," score of 5 indicated "unsure/neutral intention," and a score  $> 5$  represented "positive vaccination intention." <sup>b</sup>Items were reverse-coded (0 = "strongly agree" and 5 = "strongly disagree" with the statement), such that higher numbers corresponded to either less support for the MMR vaccine or lower MMR vaccination intent. The reverse-coded values are presented here [5- (reverse-coded value) = original value]. Abbreviations: MMR, measles, mumps, and rubella vaccine.

it is safe and beneficial). There was strong correlation among the items in each factor grouping, as shown by the Cronbach's  $\alpha$  coefficients (Table 3).

The first factor identified, which we labeled "risks versus benefits," contained 7 items and included statements addressing parents' perceived risks of vaccinating or not vaccinating their children (Table 3). These included concerns about vaccine safety, risk of vaccine side effects, and low likelihood of acquisition of vaccine-preventable diseases, especially among healthy children. In addition, items addressing lack of perceived benefits from vaccination loaded onto this factor, such as low vaccine effectiveness and preference for natural immunity over vaccine-induced immunity.

The second factor, labeled as "vaccine importance," included items addressing the potential importance of the MMR vaccine in keeping children healthy and preventing diseases among others. A statement expressing anticipated regret ("I would regret not getting my child vaccinated with MMR if they later go on to get measles, mumps or rubella") also loaded onto this factor (Table 3).

The two items relating to the potential impact of receiving all the recommended vaccines during early childhood loaded onto a third factor that we labeled "immune overload." The final factor identified, labeled "health problems," included the two items that

addressed specifically whether the vaccine would cause autism or other health problems (Table 3).

There was statistically significant variation in mean scores for the factors "risks versus benefits" and "vaccine importance" among the subcategories of parental vaccine hesitancy (Table 4). Parents with negative vaccination intentions had a statistically significant higher mean factor score for risks vs. benefits and a statistically significant lower mean score for vaccine importance, compared with parents with unsure or positive intentions. There were no statistically significant differences in the mean factor scores for the remaining two factors (immune overload and health problems) across parental subcategories.

## Discussion

Given the increasing number of vaccine-hesitant parents,<sup>1-8</sup> and the heterogeneity of beliefs among VHPs, we studied whether parents expressed different concerns and beliefs about the MMR vaccine depending on their degree of vaccine hesitancy. Interestingly, we found that, regardless of vaccination intentions, two of the most important barriers to MMR vaccination related to concerns about the childhood vaccine schedule overall rather than the MMR vaccine specifically. Furthermore, while all vaccine-hesitant parents did express reservations about MMR

**Table 3.** The factor profile of the 16-item MMR vaccine barrier survey and mean scores

Barrier	Factors				
	Mean (SD)	Factor 1 (Risks vs. benefits)	Factor 2 (Vaccine Importance)	Factor 3 (Immune overload)	Factor 4 (Health Problems)
I am worried about the safety of the MMR vaccine.	2.81 (1.69)	<b>0.74</b>	0.38	0.15	0.07
The MMR vaccine is effective in preventing the diseases measles, mumps, and rubella. <sup>a</sup>	3.39 (1.38)	<b>-0.64<sup>b</sup></b>	0.45	0.11	-0.03
My child is at low risk for getting the diseases measles, mumps or rubella.	2.81 (1.66)	<b>0.78</b>	0.12	0.13	-0.01
Healthy children don't need to be vaccinated against measles, mumps or rubella.	2.03 (1.34)	<b>0.65</b>	-0.34	-0.12	0.28
Risks from MMR vaccination outweigh the benefits.	2.38 (1.29)	<b>0.65</b>	0.06	0.10	-0.05
I would rather have my child develop natural immunity to measles, mumps or rubella than have them get the MMR vaccine.	2.68 (1.30)	<b>0.54</b>	-0.19	0.15	-0.41
Giving my child the MMR vaccine would result in a lot of side effects.	2.23 (1.38)	<b>0.79</b>	0.01	0.03	0.16
Having my child get the MMR vaccine would help to protect others. <sup>a</sup>	2.92 (1.34)	-0.00	<b>0.79</b>	-0.06	-0.23
MMR vaccines are important for keeping my child healthy. <sup>a</sup>	2.54 (1.33)	-0.45	<b>0.59</b>	0.00	0.24
I would regret not getting my child vaccinated with MMR if they later go on to get measles, mumps or rubella. <sup>a</sup>	3.08 (1.58)	0.15	<b>0.82</b>	-0.10	0.07
Children receive too many vaccines.	3.58 (1.44)	0.11	-0.10	<b>0.89</b>	-0.02
I worry that giving all the recommended vaccines will overload my child's immune system.	3.58 (1.41)	0.05	0.02	<b>0.91</b>	0.16
I'm worried the MMR vaccine will cause my child to have autism.	3.0 (1.15)	0.20	-0.08	0.23	<b>0.76</b>
I'm worried the MMR vaccine will cause other health problems.	3.37 (1.15)	0.13	-0.18	0.37	<b>0.55</b>
The MMR vaccine has not been on the market long enough to ensure it is safe and beneficial. <sup>c</sup>	2.62 (1.26)	0.32	-0.23	0.24	-0.37
I don't know enough about the MMR vaccine to decide if my child should get it. <sup>c</sup>	2.58 (1.34)	0.49	0.48	-0.02	-0.14
Factor score <sup>d</sup> : mean (SD)		2.62 (0.81)	2.85 (1.11)	3.18 (0.94)	3.58 (1.34)
Cronbach's $\alpha$		0.83	0.68	0.52	0.86

Items used a 6-point scale: 0 = "strongly disagree" to 5 = "strongly agree" unless otherwise mentioned. Bolded values in each column indicate which items loaded on that factor. <sup>a</sup>Items were reverse-coded (0 = "strongly agree" and 5 = "strongly disagree" with the statement), such that higher numbers corresponded to either less support for the MMR vaccine or lower MMR vaccination intent. <sup>b</sup>This item had an inverse impact on the factor compared with other items loading onto this factor. This item was dropped from the scale due to low factor loadings. <sup>c</sup>Factor scores were calculated as the mean of items with a primary loading on that factor. Again, items with negative correlation to other items were reverse-coded. Abbreviations: MMR, measles, mumps and rubella vaccine; SD, standard deviation.

vaccine safety, the specific concerns and their relative importance varied among subcategories of vaccine hesitancy. After grouping the barriers in our study into four underlying factors, we found that there were statistically significant differences in the degree of perceived risks vs. benefits and vaccine importance among the subcategories of vaccine-hesitant parents. Parents with negative vaccination intention had higher and lower mean scores for "risks versus benefits" and "vaccine importance" factors, respectively, than parents with generally positive vaccination intentions. Taken together, these findings demonstrate that, while all vaccine-hesitant parents have strong reservations about the growing number of recommended childhood vaccines, vaccine-specific concerns have varying salience for parents based on baseline vaccination intention. Thus, educational approaches about vaccines should likely be tailored to parents depending on their degree

of MMR vaccine hesitancy in order to improve these programs' effectiveness. It may be useful in some situations for immunization providers to formally assess vaccine hesitancy and provide educational messages based on this assessment. For example, some parents may respond better to information about the general safety of vaccines, whereas others may have a need for information specifically about the MMR vaccine. Moreover, research suggests that the more negative parents' attitudes are about vaccines, the more necessary it is for these parents to perceive that they are being provided with information about both the risks and benefits to vaccination.<sup>30</sup> Conversely, highlighting vaccination risks may be less necessary for parents with more moderate views on vaccination.

Although our study focused on parents with hesitancy toward the MMR vaccine, the top vaccination barriers that we identified

**Table 4.** Variation in factor mean scores across different categories of MMR vaccine hesitancy

Factor	Vaccination intention category <sup>a</sup>			F(2, 76) <sup>b</sup>	P-value
	Negative	Unsure/Neutral	Positive		
Risks vs. benefits: Mean score (SD)	3.32 (0.59)	2.86 (0.45)	1.84 (0.69)	40.36	0.000
Vaccine importance: Mean score (SD)	2.21 (0.96)	3.44 (0.96)	2.40 (0.98)	13.33	0.000
Immune overload: Mean score (SD)	3.88 (1.31)	3.65 (1.27)	3.31 (1.44)	0.98	0.38
Health problems: Mean score (SD)	3.44 (1.14)	3.04 (0.99)	3.23 (0.72)	1.04	0.36

<sup>a</sup>Participants were divided into three mutually exclusive categories of vaccine hesitancy based on their responses to the statement, "I plan to have my child get the MMR vaccine [at the recommended ages] if recommended by my child's doctor." Responses followed an 11-point scale, where higher values corresponded to greater agreement with the statement. Parents who responded with a score  $\leq 4$  were classified as having "negative vaccination intention," score of 5 indicated "unsure/neutral intention," and a score  $> 5$  represented "positive vaccination intention." <sup>b</sup>F-statistic for one-way analysis of variance of factor mean scores across vaccination intention categories. Abbreviations: MMR, measles, mumps, rubella vaccine; SD, standard deviation.

were not specific to that vaccine and instead reflected concerns over the increasing number of vaccines recommended during early childhood and the potential health impact of receiving multiple vaccines in a short period of time. Given that these were among the top five barriers regardless of parental vaccination intention, this suggests that all VHPs, in addition to considering vaccine-specific beliefs, take into account their children's vaccination histories and the recommended vaccine schedule when making a vaccination decision. Thus, current educational efforts that focus on describing the potential benefits and risks of one vaccine without discussing the other vaccines recommended for that child may not adequately address a parent's concerns. Instead, parents may benefit from receiving more information about how vaccine schedules are developed and the rigorous process by which additions or modifications to the recommended childhood vaccine schedule are made by clinicians and public health professionals. Effectively communicating to parents that children can safely receive more vaccines as well as combination vaccines will become of increasing public health importance given that new vaccines are on the horizon for childhood diseases such as respiratory syncytial virus.<sup>31</sup>

In our study population, perceived risks and benefits of the MMR vaccine loaded onto the same factor. Parents who reported significant concerns about the MMR vaccine may perceive less potential benefit from vaccination, and vice versa. This suggests that beliefs about potential vaccine risks and benefits are likely weighed together (or against each other) when parents are making vaccination decisions. Physician-patient discussions should aim to discuss vaccine risks and benefits contextually instead of largely focusing on intended vaccine benefits. Our results suggested that including vaccine-related risks in such conversations may actually positively impact parental vaccination intention.

An interesting finding in our study was that MMR vaccine-hesitant parents who had generally positive vaccination intentions reported lower levels of perceived effectiveness of the MMR vaccine compared with parents with lower vaccination intentions. These results warrant further investigation but one potential explanation for the apparent contradiction in beliefs is that parents may not have a strong grasp of the science behind determining vaccine efficacy. Alternatively, it may be that these issues do not carry significant weight in these parents' vaccination

decision. The potential lack of understanding about vaccines is further supported by the finding that a preference for natural over vaccine-induced immunity is a top barrier among parents who have negative vaccination intentions (and are therefore assumed to be less likely to have their children vaccinated). Thus, vaccination programs may benefit from incorporating more education about how vaccines work and why getting vaccines should be preferred over getting the actual diseases. Greater awareness among parents about how effective vaccines have been in preventing diseases may lead them to place more positive emphasis on vaccine effectiveness when making vaccination decisions.

### Limitations

There are certain limitations to this work that should be mentioned. First, the population studied was a relatively small and homogenous population of parents living in one geographic area of Michigan, and was recruited as a convenience sample (often using self-referral techniques) thus limiting the generalizability of these results. The small sample size could have also had an effect on the stability of our results (i.e., a few abnormally low or high results could skew the data) and also precluded a more in depth analysis of the factors associated with vaccine hesitancy among subgroups of parents. This is particularly relevant because our sample included parents of children up to age 6, many of whom may have already encountered the MMR vaccine decision when their child was younger (at age 12–15 mo). A larger-scale evaluation of MMR vaccine hesitancy among parents is needed, and should evaluate whether there are differences in barriers, attitudes and vaccination intention among parents who are hesitant for the vaccine and are making this decision for the first time (i.e., parents of 12–15 mo olds) vs. parents who have already made the decision once for their child, but are now hesitant for a second dose of the vaccine (i.e., parents of 4–6 y olds). The study restricted participation to parents who screened as vaccine-hesitant, which may be the most salient target population for vaccination educational efforts. However, even after screening positive for vaccine hesitancy prior to enrollment, approximately one-third of our sample indicated on the baseline survey that they would be willing to have their children receive the MMR vaccine if recommended by the child's physician. This limited our ability to focus analyses

on those parents with more negative vaccine intentions in whom interventions are critically needed to positively influence their vaccine decisions. While our analyses indicated that the barriers assessed had varying relevance depending on the parents' level of vaccine hesitancy, due to the small sample size we were not able to perform separate exploratory factor analysis among each subgroup of parents. It is possible that the factors may have loaded differently if each group of parents were assessed separately. Most importantly, the primary outcome of interest was vaccination intention, which may not directly translate to vaccine utilization. However, previous studies have demonstrated a correlation between behavioral intentions and action.<sup>32,33</sup>

## Methods

**Study population.** We performed an exploratory cross-sectional analysis of a parental survey that assessed common barriers to MMR vaccination among MMR vaccine-hesitant parents in Michigan. This survey was administered as part of an intervention trial exploring the use of individually-tailored messages in improving parental MMR vaccination intention (ClinicalTrials.gov study identifier NCT01369394), which has been described elsewhere (Gowda et al., Individually-tailored education for MMR vaccine-hesitant parents: A randomized intervention trial - Under Review).

The study population was composed of parents, guardians or primary caretakers (henceforth referred to as "parents") of children < 6 y of age who were screened during the study's eligibility assessment as hesitant to vaccinate their children against MMR. For this eligibility assessment, which occurred by phone or in person, parents were read the statement "The MMR vaccine is recommended for all children at ages 12 to 15 months and again at ages 4 to 6 years." They were then queried "Which best describes how you feel about getting your child vaccinated against MMR at these recommended times?" Parents who responded that they were "unsure" or "did not want" to vaccinate (as opposed to "did want") were categorized as MMR vaccine-hesitant and were considered eligible for the study. Other eligibility criteria included being ≥ 18 y old and able to read and converse in English.

A convenience sample of parents were recruited from pediatric primary care clinics affiliated with the University of Michigan Health System either in person via a Research Assistant placed in the clinic's waiting rooms, or by phone via self-referral to the study coordinator using contact information about the study posted in the clinics' waiting rooms. Additionally, some participants self-referred to the study via the University of Michigan's Clinical Studies website, a repository of active clinical studies. Eligible parents met with the study coordinator and were administered a computer-based "baseline" survey that assessed socio-demographic characteristics, views about potential barriers to vaccination, and baseline intentions to have their child receive the MMR vaccine. A \$40 gift card was provided as compensation. All study procedures were approved by the University of Michigan Medical School's Institutional Review Board.

**Outcome measures.** The primary outcome of interest was baseline parental MMR vaccination intention, which was assessed by responses to the statement "I plan to have my child

get the MMR vaccine [at the recommended ages] if my child's doctor recommends it." Responses followed an 11-point scale (0 to 10) where higher numbers corresponded to greater agreement with the statement (i.e., higher intention).

Parents were grouped into three mutually exclusive vaccine hesitancy categories based on their responses to the statement above. Parents who reported a score ≤ 4 on the 11-point scale were classified as having "negative vaccination intentions," score of 5 indicated "unsure/neutral intentions," and a score > 5 represented "positive vaccination intentions."

**Potential barriers.** We used previously published studies of important parental attitudes regarding the MMR vaccine to derive a series of 16 statements related to attitudes and beliefs about this vaccine.<sup>9,11-13</sup> Responses employed a 6-point response scale (ranging from "strongly disagree" to "strongly agree") and were coded such that higher values indicated stronger agreement with the statement.

**Other predictor variables.** Parents were also asked to self-report their age (< 25 y, 25 to 34 y, 35 to 44 y, 45 to 54 y and ≥ 55 y), race/ethnicity (Caucasian, African-American, Hispanic, or Other), child's age (0 to 12 mo, 13 to 23 mo, 2 to 3 y, and 4 to < 6 y) and child's gender in the survey.

**Analyses.** Descriptive statistics were derived for all predictor and outcome variables. Chi-square tests assessed bivariate associations between parental MMR vaccination intention category and socio-demographic characteristics. Mean response scores for each of the 16 potential barriers were determined for the study population overall and stratified by the subcategories of parental vaccine hesitancy ("negative," "unsure/neutral" or "positive" vaccination intention).

In order to determine whether the 16 barriers could be grouped into more general belief concepts which could then be tested for differential associations with parental vaccine hesitancy category, we performed an exploratory factor analysis. This was performed among the total sample as the sample size was too small to perform separate factor analyses for each subcategory of vaccine-hesitant parents. The factor analysis was conducted using principal components analysis with oblique rotation method (as factors were assumed to be correlated). Factors meeting the Kaiser criterion (eigenvalues ≥ 1.0) were retained. Four items were reverse-coded such that higher values consistently corresponded to less support for vaccines, and the factor analysis was rerun to facilitate subsequent analyses. Factor scores were created for each respondent by calculating the mean of the responses to all items loading onto each factor. Cronbach's  $\alpha$  coefficient was used to evaluate the internal reliability of each factor grouping. Factor-specific mean scores in each subcategory of parental vaccine hesitancy were calculated and compared using one-way analysis of variance tests. P-values ≤ 0.05 were considered statistically significant. All analyses were performed using STATA 12.0 (StataCorp, College Station, TX, 2011).

## Conclusions

Vaccine-hesitant parents identified several important barriers to getting their child vaccinated against MMR. While concerns

about the number of vaccines children receive during childhood were top barriers among all parents, the relative importance of other barriers varied depending on the degree of parental MMR vaccination intention. Taken together, these findings suggest that vaccine-hesitant parents are a heterogeneous group with varying vaccine-specific concerns that need to be more successfully addressed at an individual level in order to positively impact vaccination intention. This implies that for interventions to be most effective, parents need to be first “screened” to categorize their degree of vaccine hesitancy and subsequently provided with the most relevant educational information to counter their negative beliefs. Further studies will be needed to identify the most effective strategies that will enable health care providers to

communicate with vaccine-hesitant parents in a more targeted approach.

#### Disclosure of Potential Conflicts of Interest

Since June 2009 Amanda Dempsey has served as an advisory board member for Merck, providing advice on male HPV vaccination. This company had no role in the design or analysis of this study, and is unaware of the study's results. Dr. Dempsey does not receive research support from this company. The remaining authors have no conflicts to declare.

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